# PROPERTIES OF COMPRESSED NONFAT DRIED MILK

Instant type nonfat dried milk (NDM) is of low bulk density, 0.25 to 0.4, compared to 0.5 to 0.6 for the normal spray product. The high volume of the former, which increases container costs, shipping, and storage space, mitigates against use of instant powder in overseas shipment and in food manufacture. This report is concerned with compression of instant type powders to overcome these disadvantages. Studies of the effect of compressing powders into cake form on bulk density, dispersibility, and fragility of the cake were made.

Previous reports indicated that normal spray-process NDM could be compressed to decrease volume about 40% (2, 3, 5), but the cakes were hard and nondispersible. Experiments reported here show that some instant powders can be compressed without loss of their instant properties, whereas others are irreversibly de-instantized.

## MATERIALS AND METHODS

The compression properties of USDA foam spray dried (1), commercial spray dried, instantized and noninstantized NDM powder were investigated. The powders were held overnight at room temperature (24 to 26 C). Sixty-gram samples were placed in an open-top box-type die, which had a total capacity of 269.0 cc. A snugly fitted hard wood plunger weighing 227 g was used with a vertically attached 10-cm scale, which read zero when the die was empty. When the powder was poured into the die and the plunger placed on top of the powder, the height was easily read with the aid of a pointed indicator horizontally attached to a stand. Knowing the cross sectional area (33.5 $cm^2$) of the die, the cubic content was easily computed from the scale. By referring to Figure 1, the bulk densities could be readily determined before and after compressing.

When powder is poured loosely into a container, its bulk density is affected by vibrating or tapping the container. What is termed untapped bulk density was determined by pouring a 10-g sample of powder into a 100-ml cylinder, recording its volume, and reporting untapped bulk density according to the formula:

$$\frac{\text{weight of powder (g)}}{\text{volume of powder (cc)}} = \text{density of powder}$$

The graduated cylinder with the loosely poured powder was tapped (jolted) on a rubber stopper until the volume reached a point of no decrease, which usually required tapping for about 1 min. This density is called tapped bulk density.

The NDM was compressed by a laboratory hydraulic press. Bulk densities were determined before and after compressing. The compressed blocks (or cakes) of the powders were then crushed by use of the press and the pressure per square inch recorded as the crushing pressure. The crushed powders were put into small plastic bags and gently repowdered with a rolling pin. The bulk densities of the repowdered samples were determined and recorded. All bulk densities reported are the average of triplicate determination.

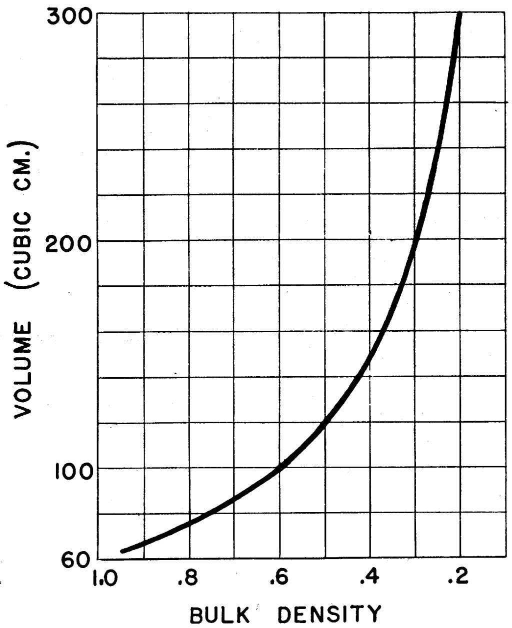


FIG. 1. Relation between volume and bulk density of NDM of 3.5% moisture.

## RESULTS AND DISCUSSION

In Table 1 the reproducibilities of density determinations of several dry milks made by the die method and by the tapped and untapped cylinder methods are compared.

The effects of compression on powder properties are shown in Figures 2-5. Curve 1 represents USDA foam spray NDM, Curve 2 a typical commercial spray instantized NDM, Curve 3 a typical commercial spray NDM.

The bulk density values determined by the die method are an approximate average of the untapped and tapped bulk densities. Triplicate determinations made by the same person fell within a range of ± .01.

In all the compressed powders, variations in the moisture content below 4% did not influence the formation of a cake or crushing and repowdering characteristics.

Microscopic studies indicate that compressing these powders crushed the individual particles. As more pressure was applied there was greater damage to the spherical particles, and large pressed aggregates were formed. These aggre-

TABLE 1

Density of NDM samples prepared by three different processes

| Type of NDM | Density of powders determined by two methods: Die method NDM 1 | NDM 2 | NDM 3 | Avg of 1-3 | Cylinder method: Untapped | Tapped |
|---|---|---|---|---|---|---|
| USDA foam spray | .316 | .319 | .320 | .318 | .30 | .34 |
| Commercial instant | .260 | .264 | .269 | .264 | .24 | .29 |
| Commercial regular | .580 | .593 | .600 | .591 | .50 | .67 |

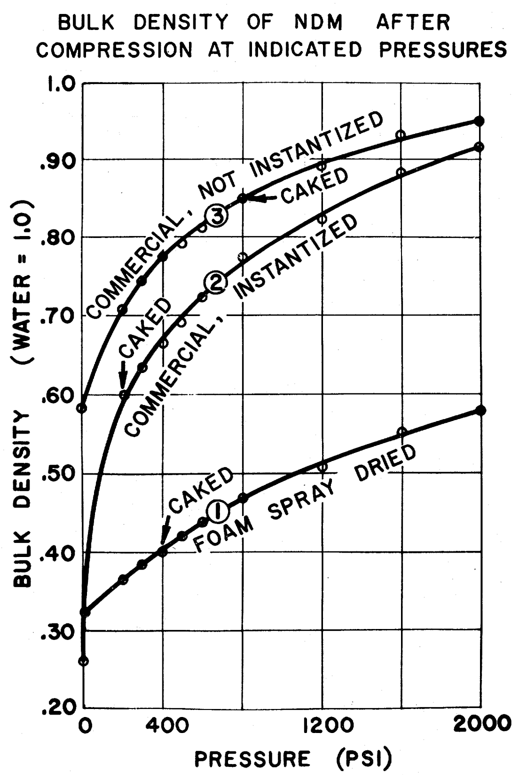


Fig. 2. Bulk density of NDM after compression at indicated pressures.

gates were difficult to disperse, but when removed from the repowdered sample by sieving, the remaining fine fraction had good dispersibility. The dispersibility of this fraction was lower than that of the original powder. This indicated that the crushed particles and the aggregates caused by excessive pressure were detrimental to good dispersibility.

The USDA foam spray NDM withstood pressures between 500 to 600 psi, formed a cake that could be handled, repowdered readily, and retained its original dispersibility (Figure 4). The bulk density of the compressed cake was .45.

The commercial instantized type of NDM was readily compressed into a cake that could be handled at pressures between 200 to 300 psi.

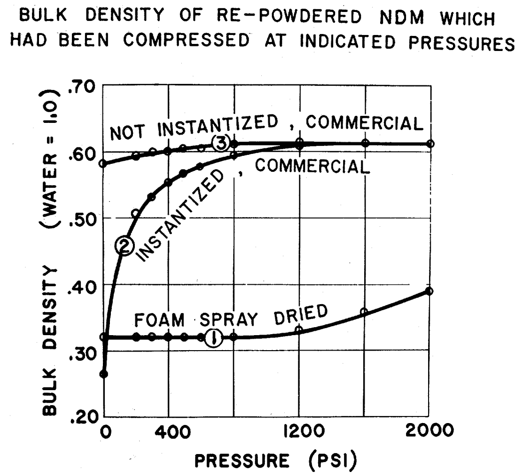


Fig. 3. Bulk density of repowdered NDM compressed at indicated pressures.

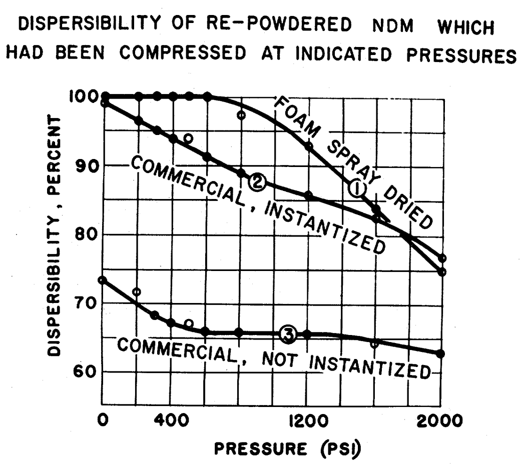


Fig. 4. Dispersibility of repowdered NDM compressed (5).

It could be repowdered readily. The sinkability characteristic of this powder was lost, but its dispersibility was only slightly impaired. The bulk density of the compressed cake was .60.

The commercial or regular spray NDM re-

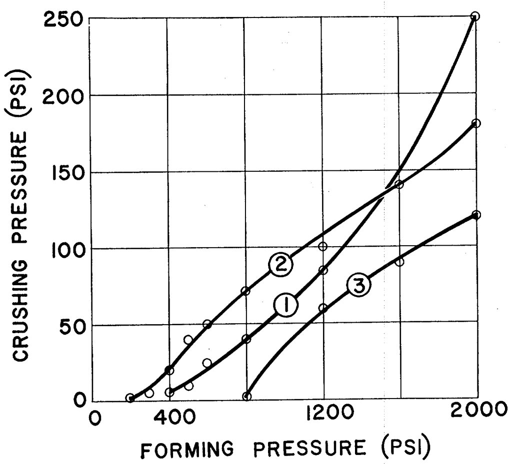


FIG. 5. Pressure required to crush powder cakes formed at the pressures indicated.

quired from 900 up to 1,000 psi to form a cake that could be handled. This pressure was excessive and aggregates formed which greatly decreased powder dispersibility. The cake was difficult to repowder.

The low bulk densities of some types of instant powders increase packaging costs. By reducing volume without destroying the particle structure and without lowering dispersibility these higher costs could be reduced.

Another space-saving possibility might be to press lightweight powders in the barrels or drums ordinarily used for regular heavier weight products. A retail package could be prepared in compressed cube form which would provide the exact amount of powder for a pint or quart of milk.

Since the USDA foam spray NDM particles withstand considerable compression, they will also survive rough handling, in contrast to the fragility of the agglomerated spray type. The foam spray powder can be bagged for shipment and can be stacked in warehouses without particle injury.


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